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Chapter Two

CLIMATIC FACTORS IN SOUTHEAST ASIA

FEW regions comparable in size to Southeast Asia have so uniform a temperature régime over the whole area and throughout the year. Apart from those local variations due to altitude, and in Northern Burma and Siam to continental influences from Tibet, Southeast Asia from Lower Burma to Cochinchina and New Guinea has average monthly temperatures which remain within ten degrees or so of 80° F. at all seasons. Symmetry about the Equator and a set of land units thoroughly broken up by water bodies of greater area than themselves account for this uniformity of warmth in time and from place to place, and in turn mean that the broad human and vegetation variations do not correlate closely with variations of warmth from place to place, nor is the rhythm of vegetation and cultivation in the region as a whole set by an annual procession of temperature changes.

The basic rhythm of plants and agriculture through most of Southeast Asia is dominated by rainfall—by its incidence rather than by its volume, though considerable differences in volume make distinct climatic sub-divisions away from the axis of the Equator. Köppen's classification emphasises these climatic differences. In this broken terrain, the pattern of the rainfall and the pattern of its variations within short distances, are set by the wind systems. To understand these is to see the operative factor behind the local differences in rainfall periodicity which very much depend on the aspect of the land masses in relation to the seasonal air currents and to local water areas.

THE WIND RÉGIME

Two similar air masses move across Southeast Asia:

(*a*) The Northern Tropical Air Mass which normally moves from the Tropic of Cancer towards the Equator as the Northeast Trades;

(*b*) The Southern Tropical Air Mass, originating over the Tropic of Capricorn and normally moving towards the Equator as the

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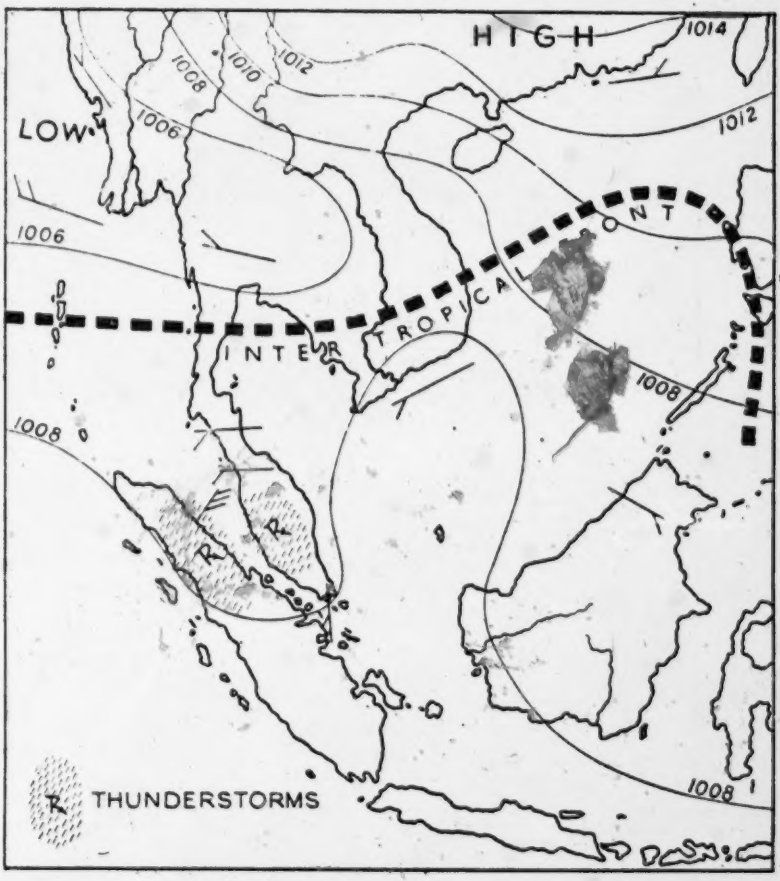

FIG. 8.—Daily Weather Chart of Southeast Asia with isobars in millibars at 12.00 on 28th September 1946

Southeast Trades.

The physical character of the air is much the same in these two masses, which each have long courses across extensive warm seas, so that each is uniformly warm and uniformly damp. Furthermore, the air masses are both losing impetus as they move into lower latitudes. Where the Northern and Southern Tropical Air Masses converge is thus a front, by analogy with conceptions regarding air convergences worked out in other parts of the world, e.g. the Polar Front. The surface of convergence of the two tropical air-streams may be called "The Intertropical Front" and it shows on the weather map as a line.

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The similarity of physical conditions in these airstreams means that the Intertropical Front is less sharply defined at any one time by comparison with the Polar Front which separates air masses in different physical states. The warmth, the humidity and the loss of horizontal impulse in each of the Tropical Air Masses mean that vertical impetuses are increasing so that the Intertropical Front is marked by upward movements on both sides, tending to a vigorous convectional action. This explains the frequent calms along the Intertropical Front when strongly developed in what may be called its "ideal position," i.e. roughly along the Equator. In the older terminology, the zone of convergence of the Trade Winds was called the Doldrums. Just as the Polar Front has been found extremely useful in forecasting depressions in more northern latitudes, so also the Intertropical Front is a valuable line for forecasting weather, since along it move mild depressions and squalls which may assume great violence. Daily weather charts (synoptic charts) in this zone have so far only been prepared for official use and are not sold publicly (Fig. 8).

This relatively simple pattern is complicated by two other influences. Firstly, the two air masses are displaced across the Equator by the annual migration of the sun. The Intertropical Front is thus pulled south during the Southern Hemisphere summer and north of the Equator during northern summer. When the airstreams cross the Equator, Ferrell's Law operates upon them differentially so that Southeast Trades moving into the Northern Hemisphere become southwesterly winds and Northeast Trades become northwesterly winds when moving into the Southern Hemisphere.

Secondly, the low pressure areas developed over the continents to which Southeast Asia is marginal, induce certain seasonal deviations in the air streams. Summer low pressures over Australia are just strong enough for the Intertropical Front to be pressed abnormally far south over Northern Australia in December. But the summer low pressures over India and the margins of continental Asia, particularly over Central Burma and Central Siam, have more dramatic effect: the Northern India low pressure system draws parts of the South Tropical Air Mass over the Equator in late northern spring, to maintain a parabolic path over the North Indian Ocean until November. The low pressure system which becomes established over the eastern parts of Asia two or three

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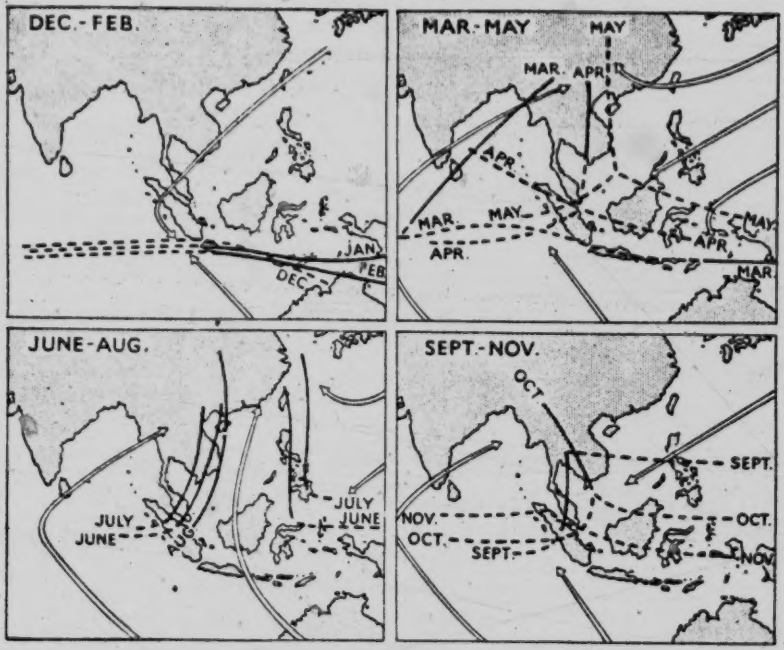

FIG. 9.—The Intertropical Front in Southeast Asia. The front is shown by a heavy line, drawn as continuous where it is sharply defined and persistently located; as an interrupted line where the front is weakly defined and subject to considerable variation in position. The open lines show diagrammatically the manner in which the air masses move

months later than that over India, has a somewhat similar effect, drawing Southern Tropical Air far northwards through the South China Sea during June-July-August.

These influences produce the air streaming ahalysed in the accompanying four maps (Fig. 9), each representing conditions over three-month periods, which may be summarised thus:

1. December to February. The Southern and Northern Tropical Air Masses at this period move almost on ideal lines. The northern air streams cross the Equator as northwest winds reaching to about 7° S. where the Intertropical Front runs almost latitudinally except for a sag farther south towards the Australian low pressure zone.
2. March to May. Three air streams interact at this time. The Southern Tropical Air presses northward but does not substantially cross the Equator near Southeast Asia. The Northern Tropical Air Masses withdraw towards the northeast and in

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places more towards East Asia as east winds. Over mid-Indian Ocean, a first part of the Southern Tropical Air Mass (under the influence of Indian low pressures) crosses the Equator to blow across the Bay of Bengal as southwest winds, reaching farther eastwards as the season advances. The Intertropical Front at this time has branched form; its trace becomes roughly a cuspate curve pointing northward and prolonged in that direction by one or two arms which mark the convergences of air streams from the Bay of Bengal and from the West Pacific. The crux of this front is over the Central Indian Ocean in March, moving to positions eastward and slightly northward to one off Labuan in May.

3. June to August. Southern Tropical Air increases its migration north and a second major transfer of it into the Northern Hemisphere takes place, driving through the Java Sea and the South China Sea, drawn far northwards by East-Central Asia low pressures. At this time Northern Tropical Air does not reach Southeast Asia. The Intertropical Front opens into two almost symmetrical fronts of hyperbolic shape as a result of the second streaming of South Tropical Air. The double arms of the Fronts are close together at first but the distance between them increases until during August only the western portion lies over Southeast Asia as a roughly N-S. curving front off the coast of Indochina. The Intertropical Front persists over the Malaya-Indochina area throughout this quarter, delimiting two air streams both of which are Southern Tropical in origin yet which have acquired different physical characteristics and directions by taking different courses.
4. September-November. At this season the Northern Tropical Air rapidly increases its pressure from the north, extending its coverage westward and southward. Southern Tropical Air continues to cross the Equator over the Indian Ocean but diminishes in drive, to cease as an air transfer by November. The streaming of Southern Tropical Air through the South China Sea becomes completely occluded and is finally confined below the Equator as the Southeast Trades. Moving southward, the Intertropical Front reverts to the cuspate form of March-May, flattening to a latitudinal alignment. At this transitional period the cuspate curve is much sharper at its beak and less symmetrical than in the spring.

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132 In considering this analysis of tropical air masses, it must be remembered that the Intertropical Front varies in its preciseness and the positions given here are tendencies often disguised in practice by broad zones of calms. Thus the Doldrums should be considered as the zone within which is located the Intertropical Front, characterised by highly unstable air conditions and traversed by weak depressions moving sometimes westwards, sometimes eastwards, or at certain seasons polewards under the influence of the adjoining continents.

Rainfall

In Fig. 10 the generalised effect of aspect, relief and these air streams may be seen to produce a rainfall above 80 in. per annum upon most territories of Southeast Asia. The zones of low rainfall are the dry belt of Upper Burma and South-Central Siam which are shielded by relief barriers athwart the air streams. Moreover the total precipitation lessens eastward in the East Indian areas, particularly in the territories and islands east of Central Java.

North of a line from Achin through North Malaya to Mindanao, and east and south of Central Java, very distinct dry seasons appear, the criterion being that of Köppen: at least one month of these areas has less than 2.4 in. of rain. The disposition of these dry zone areas is related to latitudes beyond the equatorial belt and towards the tropical limits. Towards the Equator, precipitation varies seasonally, generally with double wet seasons, though no season is sufficiently rainless to be called dry.

The tropical air masses operating over Southeast Asia are characterised by high temperatures and humidity, coupled with a physical instability which is greatest towards the Equator and decreases towards the continent of Asia. As a result of this instability, relatively weak depressions, small relief features and local overheating by insolation in, say, a town or in bare fields, can act as triggers to stimulate violent vertical air movements. Altitude thus has greater effects proportionally than is normal in other latitudes. Under these conditions cumulo-nimbus clouds of as much as 10,000 ft. depth may develop within half an hour and vertical air currents of 100 m.p.h. inside such clouds are quite common. With the parent air so humid, the precipitation consequent on such updraughts is very heavy (often as much as 2 inches

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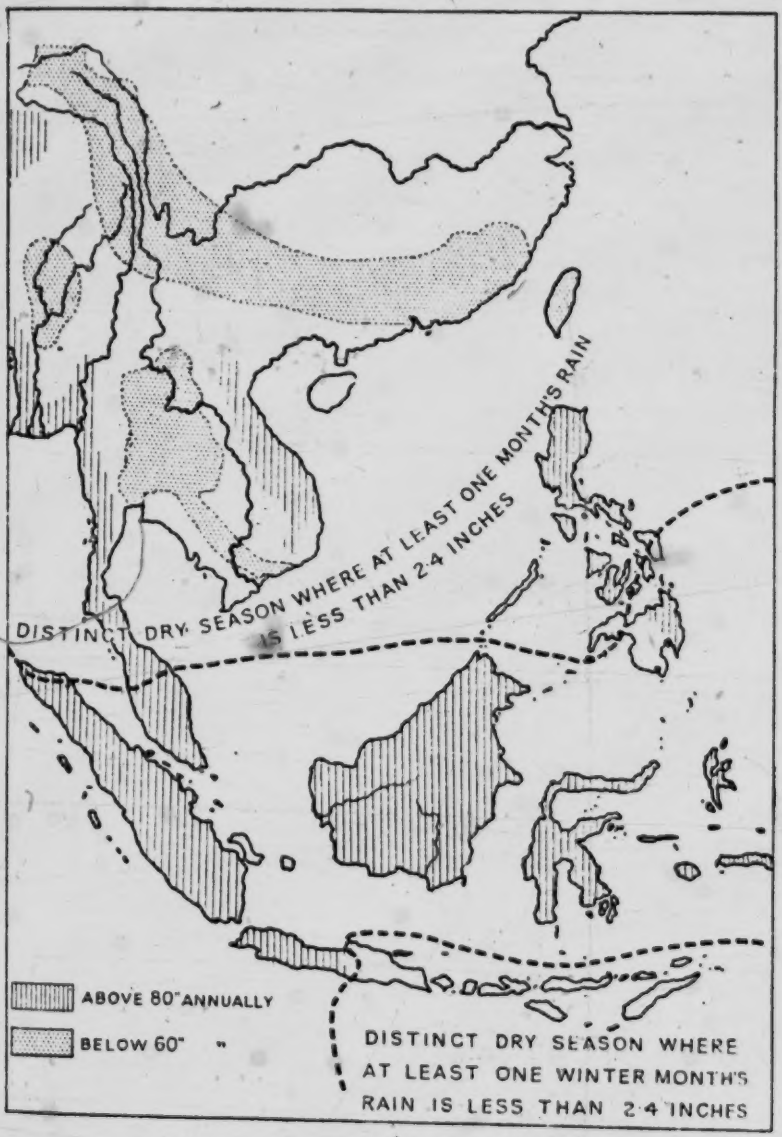
DISTINCT DRY SEASON WHERE AT LEAST ONE MONTH'S RAIN IS LESS THAN 2·4 INCHES
ABOVE 80" ANNUALLY
BELOW 60" "
DISTINCT DRY SEASON WHERE AT LEAST ONE WINTER MONTH'S RAIN IS LESS THAN 2·4 INCHES

FIG. 10.—Climatic Factors of Southeast Asia

within an hour) even though localised over a small area, and the latent heat deriving from precipitation serves to perpetuate the uprush of air. While all types of initial cause of precipitation occur over Southeast Asia, they tend always to be accompanied by

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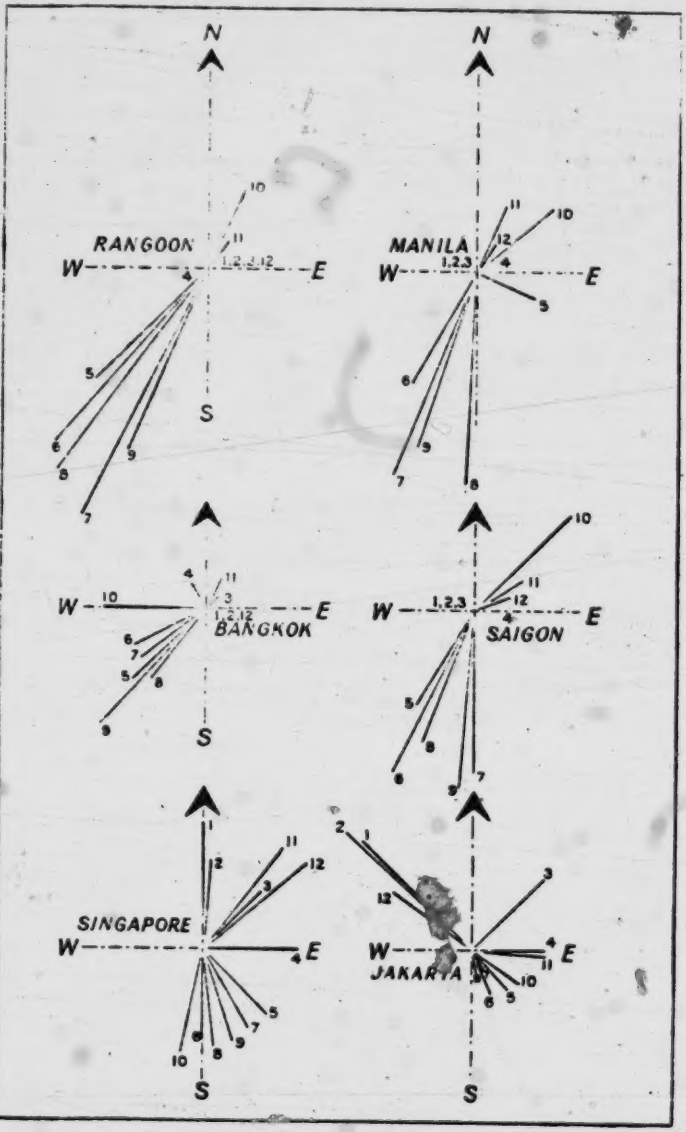

FIG. 11.—Correlation of Rainfall and Wind Direction in Southeast Asia. The bearing of each arm represents the mean monthly direction of the wind (blowing towards the centre) and the length of each is proportional to the mean monthly rainfall. Months of no rainfall are thus no more than points at the compass centre. The numbers on each arm indicate the month (1 Jan., 2 Feb., etc.)

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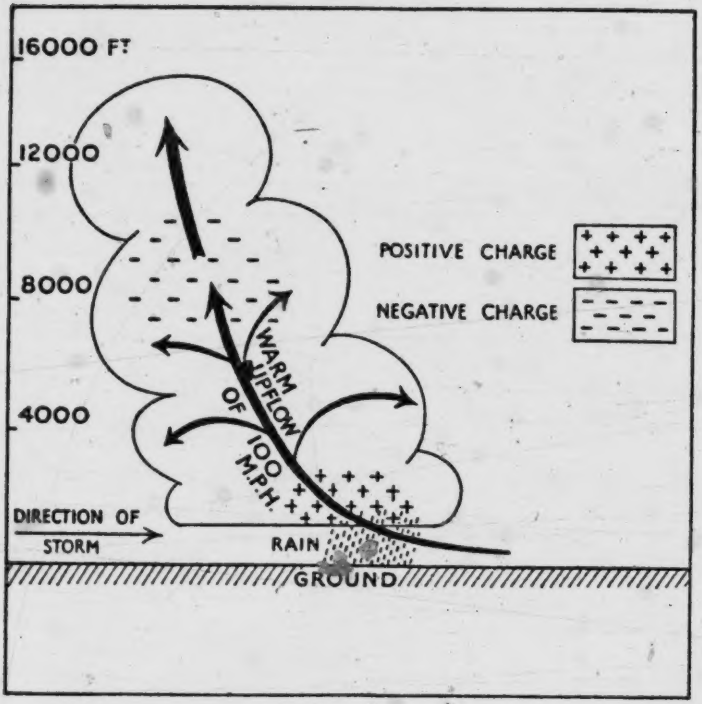

FIG. 12.—Structure of a Tropical Thunderstorm

thunderstorms, which towards the Equator are of daily occurrence and great violence (over 320 storms occur at Buitenzorg each year). Thunderstorm frequency decreases in those sub-regions where winter dry seasons are pronounced, yet even there the rainy months have high thunderstorm frequency. These Southeast Asia thunderstorms resemble those of middle latitudes (Fig. 12) and are accompanied by a "chimney" of rapidly rising air at the core, often with downflows of cooler air just in front of the storm. While the up-current of these thunderstorms is strong enough at times to tear an aeroplane apart, the freezing level is so high (above 25,000 feet) that hail, a common feature of similar storms in other latitudes, is here rare. The degree of correlation between rainfall and wind is evident from the combination of wind-roses and rainfall data in Fig. 11 which also demonstrates how emphatic is the dry season at places away from the Equator.

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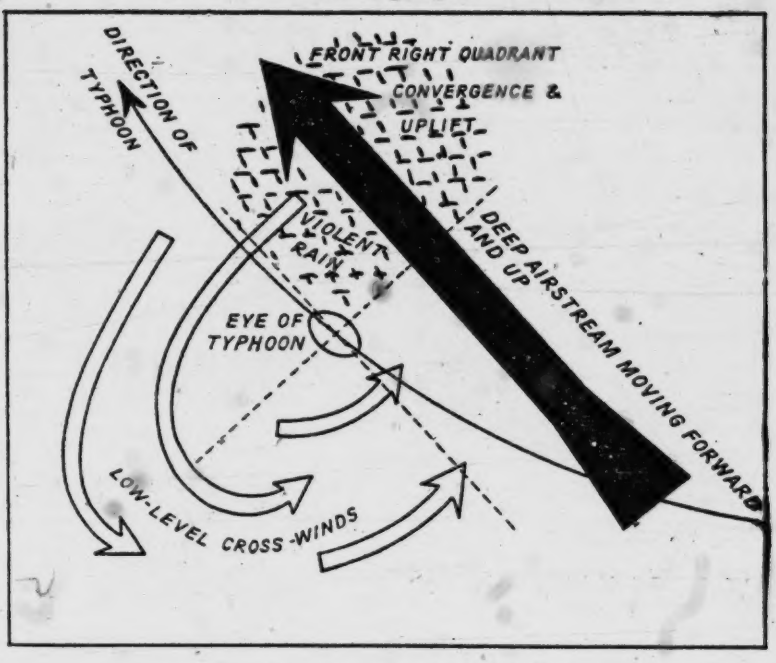

FIG. 13.—Theoretical Structure of a Typhoon

TYPHOONS

"Typhoon" is the name given to tropical cyclones which occur off East Asia. Only the northernmost parts of Southeast Asia come under the influence of typhoons which are most frequent over the Philippines and Indochina. A few have been known to cross the Kra Isthmus and pass over Bengal. The Bay of Bengal typhoons, frequenting a restricted area well north in the Bay, do not normally affect Burma, so that only the South China Sea typhoons strongly influence the weather conditions of Southeast Asia territories.

While theories about the origin of typhoons do not reach general agreement in detail, partly due to the difficulty of obtaining full meteorological data about these phenomena whose violence so often destroys instruments and whose variable paths defy advance preparation for tests, they seem to result from a widespread convection of hot, moist, unstable air and may represent extreme variants of the forces arising from convergent air currents. Much has been done to accumulate data about sea level features of

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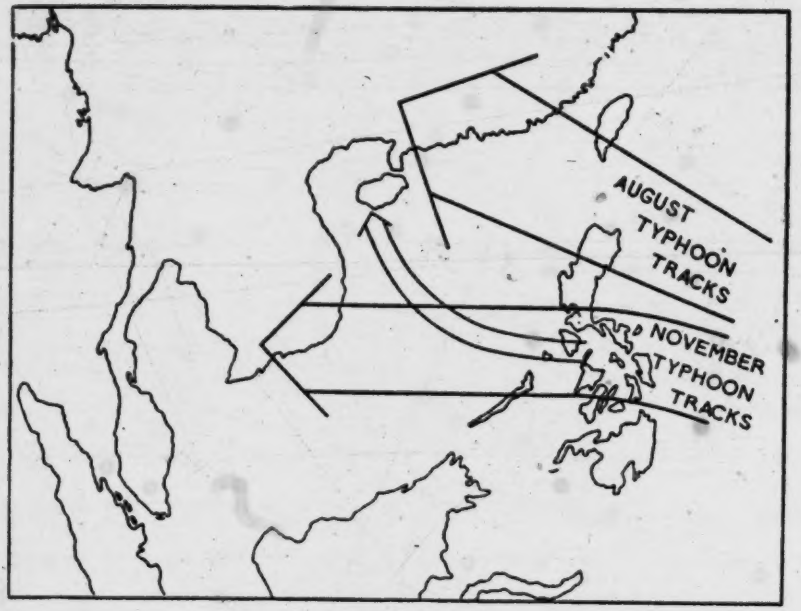

FIG. 14.—Typhoon Tracks in the South China Sea

typhoons, but little information is available about their vertical structure apart from navigators' notes on cloud formation. Clines, writing on the basis of U.S. data, seems to have established that typhoons are in fact largely self-perpetuating from the release of much latent heat due to violent precipitation in the front right quadrant, where he suggests a point above the ground at the precipitation level is in effect a constant generator of heat, and a constant low pressure focus towards which the sea-level barometric centre is always moving (Fig. 13). A close relation between the path of typhoons and a front between air masses has also been suggested.

Typhoons of the South China Sea normally originate somewhere east of the Philippines and travel towards those islands and Indochina, along paths which gradually assume that parabolic line peculiar to all tropical cyclones, so that somewhere between the Philippines and Tonkin they begin to recurve on a line towards the northeast (Fig. 14). The seasonal incidence varies. In the period 1918-29, ninety-eight South China Sea typhoons were distributed thus through the year:

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	Jan.	*Feb.*	*Mar.*	*Apr.*	*May*	*June*	*July*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*	*Total*
Number of Typhoons	2	0	0	0	4	6	22	17	11	15	15	6	98

The peak periods, July to November, relate to the abnormal positions of the broken Intertropical Front as shown in Fig. 9. Regarding the mean tracks of these East Asia typhoons, it will be noted that they normally move on paths shifting progressively northward from February to August and shifting southwards thereafter until January, but they never reach much farther south than the Cape of Cambodia. From July to September the maximum danger zone for typhoons is north of latitude 15° (Luzon and the Gulf of Tonkin) while in October and November maximum typhoon risk is on the coasts of Cochinchina and the extreme south of Annam.

South China Sea typhoons have characteristics like those of similar disturbances elsewhere. In advance of them whispy cirrus clouds at high altitude and broken cumulus clouds at lower levels drift across the horizon, the latter becoming dark rugged clouds, more numerous and coalescent in the centre as the typhoon approaches. About 100 miles from the centre, dark nimbus clouds develop and produce torrential rains moving forward with the whole typhoon at rates from 10-20 knots, while the constituent winds often increase to speeds reaching and exceeding 80 knots. Each typhoon has an "eye" of comparatively small area, perhaps 5 miles in diameter where the sky is relatively clear, calmer or only lightly squally and no rain falls, resembling an intensified form of the quiet conditions between the warm and cold fronts of a middle latitude cyclone. Behind the "eye" of the typhoon winds again blow with devastating violence, in a reverse direction to winds in advance of the "eye," with nimbo-stratus clouds producing torrential rains which reduce visibility to nil. These gradually lose intensity and the typhoon passes over, leaving a trail of high cirrus.

In these deep tropical depressions, the great force of the winds involved causes widespread damage in built-up and cultivated areas. Their violence and frequency is particularly great in Luzon and they appear to lose violence over Indochina. They form one of the major hazards of shipping in the South China Sea, particularly

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for native sailing vessels. Most of the first study of these typhoons was contained in European seamen's handbooks which were chiefly concerned with rule of thumb methods by which ships unlucky enough to be caught in a typhoon could avoid the most dangerous parts of them. The coastal zones of Tonkin and Annam experience severe floods in low-lying areas when the typhoon winds set in certain directions which augment the tides. Typhoon winds can, at their worst, lift trains from their rails and cast steamers several hundred yards inland from the shore.

The French observers, Bruzon and Carton, describe thus a typhoon over Nha Trang and Hon Ba in 1926: "The typhoon appeared first on 2nd November, WNW. of Yap and on the 3rd was 700 km. east of Manila. During the night of 5th-6th November it crossed south of Manila. Over the China Sea, its course changed from west to west-southwest and the typhoon struck the coast of Annam on the 7th. At Nha Trang about 16.00 hours on that day, the wind blew violently from WSW. During the night its violence increased and its course changed through NW. and N. to NNE. Minimum pressure was experienced that night (980 m.b.) but at Hon Ba in the mountains (1,480 m.) pressure went down two hours later to 818 m.b. During that one night pressures dropped about 30 m.b. in the path of the typhoon but after a few hours reverted to normal again. Considerable damage was done to Hon Ba forests, many trees were uprooted and in some places entire groves were destroyed. The typhoon brought torrential rain to the whole Annam coast from Faifoo to Cap Padaran."

Certain line squalls moving eastwards to Malaya at very low latitudes in the Malacca Strait have a violence at times approaching that of typhoons and the squalls are in fact related to disturbances on the Intertropical Front: they are not circular in character, have no "eye," are not extensive or persistent features and they have no connection with true typhoons.

Sunshine

Over most Southeast Asia territories for much of the year, the cloud cover is very heavy and the sunshine period is low. This is most emphatic towards the Equator away from which a season of clear skies and continuous sunny weather occurs. The effective sunshine

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132 is rendered even less by the high humidity which cuts off many actinic wavelengths. In Singapore over half the sunshine day is obscured by clouds; in Jakarta less than 70 per cent of the possible sunshine hours are sunny. A distinct diurnal rhythm of sunshine incidence is characteristic of the Equator; during the mornings, which frequently begin clear and sunny, cumulus clouds steadily increase to a maximum in the afternoon, when convectional influences are at their peak, often producing thunder-showers followed by a clearing of the sky towards sunset. The amount of sunshine received is normally greater at sea level and decreases with altitude. On the other hand, those districts with distinct dry seasons have high sunshine values in the dry periods, often offset on the average by prolonged obliteration of the sun during the rainy season. These factors have considerable agricultural significance.

Humidity

High average humidity values are normal everywhere in Southeast Asia, but they are subject to frequent variations. Coasts are damper than interiors and highlands are damper than plains. Localities with marked dry seasons have periods of low humidity accompanied by high temperatures. In any one place a few hours sunshine rapidly lowers the relative humidity and it is a fact that even in the wettest places, the ground and wet clothes dry out under direct sunshine. Comparatively minor humidity variations have considerable effects on plants, and from the point of view of human beings it is the humidity rather than the temperature which produces feelings of body heat or body cold. When the relative humidity drops a few points, the skin sensation is one of coolness, due to easy evaporation of perspiration. By the same cause, a site exposed to regular breezes feels drier and cooler than the actual humidity or thermometer figures justify. The generalised rainfall and seasons map (Fig. 10) is a convenient guide to the distribution of humidity.

Altitude Effects

133 Throughout the region altitude is an important factor varying
132 the local weather conditions. While the land masses are relatively small, they are orographically very broken so that (apart from

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East Sumatra) no very extensive plains have developed and mountains are visible from most points. Even the highest peak known (Kinabalu, Br. Borneo, 13,681 ft.) lies well below the snow line but those highlands adjoining Yunnan do receive a brush of snow in winter. The average highland is, however, more

CHINA
Cw warm temperate rainy climate with at least ten times as much rain in wettest summer month as in driest winter month
Cf warm temperate rainy climate with no distinct dry season
Amw
SIAM
Aw tropical rainy climate with at least one month of dry season receiving less than 2·4" in that month
FR. INDO-CHINA
Amw tropical rainy climate with short dry season but total rainfall enough to support rain forest
PHILIPPINE IS.
Manila
SOUTH CHINA SEA
Afi
MALAYA
Singapore
BORNEO
Cf
Equator
tropical rainy climate with no month receiving less than 2·4" rain and less than 9°F. difference between warmest and coldest months
SUMATRA
CELEBES
Jakarta
JAVA
Awi tropical rainy climate with at least one month of dry season & less than 9°F. difference between warmest & coldest month
MILES
100 0 100 300 500

FIG. 15.—Köppen's Climatic Regions in Southeast Asia

of the order 8,000 feet and continuous areas at a high altitude are quite small. These altitudes induce local temperature reduction, more evident at night than during the day, and local high humidities. They cause local rain shadows which, owing to the differing winds through the year, are seasonal rather than permanent, except where double ranges give the intervening lowland a fairly constant rain shadow, as in Central Burma. A major function of the higher altitudes is to cause orographic rains and to lower the temperatures, which latter has less geographical significance than the overall raininess.

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Climatic Regions

132 Raininess is the basic criterion between major parts of this climatic area where temperatures are for most regions never less than warm. Two broad rain types may be distinguished:

(*a*) heavy rains at all times of the year (over 80 inches per annum). In detail there are peaks of raininess, generally double peaks, but between these peaks is a season less rainy, though still without any month which may be called dry. This region is mainly equatorial.

(*b*) rains through most of the year, with at least one month with less than 2.4 inches during these cooler months, the length of dry seasons increasing with latitude and the limits being roughly latitudinal as in Fig. 10. The dry seasons are normally related to wind streams at various times of the year. This zone subdivides into:

1. A subdivision where total rainfall is exceptionally low (below 60 inches per annum) and the drought season long, as in Central Burma and East Siam.
2. A subdivision where the dry season is long and altitude reduces the temperature to less than about 60° for the cool season, but not reaching freezing on the average.

Köppen's classifications for this zone are a convenient but by no means fully checked scheme (Fig. 15).

Chapter Three

THE DRAINAGE PATTERNS OF SOUTHEAST ASIA

THE Irrawaddy, Salween, Menam Chao Praya and Mekong are remarkable for their length compared with most Southeast Asia rivers, which rarely exceed a few hundred miles long. Those four major rivers are associated with tectonic basins; relief elsewhere only permits short streams. All districts marginal to the Sunda Platform have experienced relatively recent tectonic changes and the rivers developed upon them are youthful as well as short. Upon the Platform itself much more advanced landscape maturity is evident but because this older surface has only limited areas exposed, rivers even there are short.

CHARACTERISTICS OF TROPICAL RIVERS

In the régime of tropical rivers several factors have distinctive emphasis compared with conditions in temperate latitude rivers. Firstly the volume of water precipitated into and to be carried from any drainage basin is several times that of equivalent temperate latitude rivers as a result of the much higher rainfall. Moreover the precipitation is more intense. Even the dry interior of Burma experiences falls of rain averaging ·6 inches per rainy day. The water content of those Tropical Air Masses over Southeast Asia is so high and the rising air currents so strong and sustained that several Javanese stations have recorded falls of over 16 inches per day. These violent torrential downpours are often very localised at any one time, yet on an average they affect large areas. Thus the volume of rainwater in any drainage basin is enormous and fluctuates widely within short periods of a few hours.

A further consequence of these great rainstorms is their powerful erosive effects. Upon cultivated land the force and volume of these downpours cause surface downwash to be large, the soil rapidly washes away and whole hillsides may slip, so that the run-off has a high mud content. Because the rivers are mostly immature, this heavy load may be sustained by turbulence for considerable

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distances. In areas of alternating wet and dry seasons, drought cracks the ground, loosens the top surface and thereby increases the available load when the rains begin. The Dry Zones of Burma and Siam are for this reason areas of most violent surface removal. The very heavy load of Southeast Asia rivers gives them a great capacity for rapidly building up deltas, sedimenting the estuaries and at times causing heavy deposition of silt well inland. Furthermore the rainfall is not only violent and intense, it is also variable in seasonal incidence; thus many streams of Upper Burma, Central Siam and Eastern Java are for months practically dry and then come into spate within a few hours, not unlike the wadis of North Africa. Landform combined with the seasonal rains causes the Salween, for instance, to vary its level 50 feet within a few hours. Such variability of volume induces deposition well inland. Huge silt banks lie across many watercourses, vast alluvial fans develop at the debouchment to plains, and even at the junction of tributaries.

The Irrawaddy presents an example of how the drainage conditions differ at different points in the course of a tropical river. Near and above Bhamo changes of Irrawaddy level directly parallel changes of rainfall. As the stream passes through the Dry Zone of Burma it receives no significant additional water from the tributaries after it passes the confluence of the Chindwin and it is effectively losing water by evaporation. Stamp estimates 45 per cent of Irrawaddy water has been lost by evaporation when the stream finally reaches the head of the Delta. Evaporation rates in the Burmese Dry Zone are little, if at all, less than the precipitation. Farther downstream, in the Delta, heavy precipitation occurs again, so that the Irrawaddy floods arrive at the Delta roughly a month after peak rains in the reaches above Bhamo, to find it already suffering from floods due to local rains and small local streams. These floods of local origin effectively oblige the Irrawaddy water to remain within the main distributaries. Even more interesting is Stamp's evidence that the average annual silt load at the Delta head is 261 million tons, whereas at Mandalay it is only 32 million tons, showing that 229 million tons of silt is added in the Dry Zone. Since the Chindwin provides 109 million tons of silt, the balance of 120 million tons derives from the wadi-like, highly variable streams (chaungs) joining the Irrawaddy in its driest section.

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Chapter Four

SOUTHEAST ASIA'S NATURAL VEGETATION

Tropical Forest Factors

The heavy, evenly distributed rainfall and constant high temperatures of most of Southeast Asia encourage continuous plant growth and a profuse, very varied flora. Because the whole year is here a growing season, plant life becomes almost overpowering in its rate of growth. This region contains more species than any other; the flora is not yet completely known, but some 35,000 species of flowering plants alone are thought to exist there (van Steenis). On Borneo at least 11,000 species have been listed, according to Merrill. This contrasts with the parallel figure of 13,000 species for the whole of Tropical West Africa (Good). Woody plants predominate and 15 per cent of the species are trees whose mature trunks are over 16 in. in diameter. The profusion of species is due to (*a*) the predominantly warm, moist climate, (*b*) the constancy of this climate over long geological periods, (*c*) the variety of relief and islands producing minor adaptations, (*d*) the rapidity with which selective and adaptive evolutionary processes can establish new characteristics in a tropical climate which has no resting season, and (*e*) the migrations of plant types from both Asia and Australia.

Southeast Asia was originally clothed by nature almost entirely by a tree cover. Only in modern times has there been any extensive clearing because apart from firing, primitive people were technically incapable of removing the forest. Some clearings became permanent for cultivation, in recent centuries, but the majority have been temporary and partial clearings, later left to natural replacement by a selective vegetation such as grass, savannah or scrub. Temporary clearings resulted largely from systems of shifting cultivation which finally abandon an area, partially cleared by fire, to a series of quick-growing plants, becoming after a few years a secondary forest which may, over prolonged periods, evolve to be scarcely distinguishable from primary forest.

The system of migrant agriculture or shifting cultivation, in Malaya called *ladang* and in Burma *taungya*, is widespread through-